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PASSIVE ARCHITECTURE AND ITS IMPACT ON CARBON EMISSIONS

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ABSTRACT

Passive architecture works with the natural environment and building design and materials to minimize the amount of energy required, therefore reducing carbon emissions. A need for less energy consumption in residential and commercial buildings allows for a greater reliance upon energy sources that may produce less electricity but are renewable (solar, wind, etc.) can be used. This report examines the impact of the building and construction industry on carbon emissions and, subsequently, climate change. Methods and materials used for construction must be considered, as must the methods used for the assessment of carbon output. When striving to reduce the carbon footprint of the construction industry, it is important that the materials used in the construction are produced sustainably, as well as the way in which materials are utilized in the design and actual building. Finally, identifying and studying power and energy sources that minimize carbon emissions must be a prerequisite to any passive architecture project.

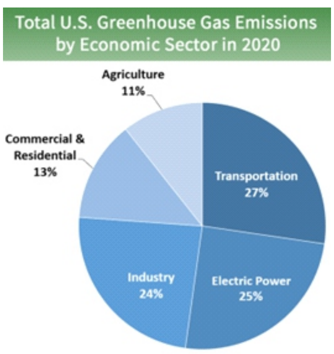
KEYWORDS: Passive Architecture, Energy, Carbon Emissions, Sustainable Design.

INTRODUCTION

What is Passive Architecture?

Passive architecture, by definition, works with nature to heat and cool buildings but also includes considerations about how buildings are constructed and how the materials used in their construction are created. This reduces the amount of energy needed to power the building, which also allows us to use energy sources such as solar and wind. In considering ecologically conscious architecture, we also remember the philosophy of architect Sim van der Ryn, who taught that "buildings are not objects but organisms, and cities are not machines but complex ecosystems" the process of which "begins not with numbers and metrics but through creating a shared agreement of aspiration and intention, opportunities and constraints." (Ryn & McLennan, 2022).

Homes produce about 45% of all U.S. carbon emissions, and nearly 90% of those emissions come from fossil fuel-powered temperature control (Montjoy, 2022). It is because of this that we need a temperature-neutral, carbon-neutral, energy-efficient passive architecture that incorporates technologies like solar and Trombe walls, which introduce superinsulation layers that naturally regulate indoor temperatures. With these tools, it is often possible to create more energy than is being used by the building itself. Passive architecture is not a new concept but has been utilized and developed since humans needed shelter. By restoring some of the methods of ancient architecture and combining these with modern technologies, we can achieve more ecologically sound buildings that protect and reverse damage to our climate. Passive architecture is an answer to reducing carbon emissions worldwide.



Total Greenhouse Gas Emissions by Economic Section (2020)
Source: Montjoy (2022)

The Construction Industry & Carbon Emissions

The construction industry produces an estimated 19% of all greenhouse gasses (GHGs) on a global scale. However, there are weaknesses within the current studies available on this topic. As pointed out in a literature review in the *Journal of Sustainable Construction Materials and Technologies*, titled "The Carbon Footprint of the Construction Industry: A Review of Direct and Indirect Emission," the majority of these papers focus on a particular region or country (Mathur et al. 2021) without supplying a reliable overview of the subject. In addition, the methods used for assessment may not be standardized. One such paper says that "Adopting sustainable concrete production and usage strategies not only reduces greenhouse gas (GHG) emissions but also decreases consumption of energy and water" (Arioglu et al, 2017).

Some of the sources that produce GHGs are, as mentioned above, concrete and steel. Concrete can be produced using various methods, some of which produce more GHG than others. Furthermore, the use of lumber in construction affects the total carbon emissions of buildings when deforestation of the planet is considered. Wood alternatives such as fast-growing bamboo and hemp, plastic lumber, wood composites, foam board, and rubber offer economical and more ecologically sound options that may assist in slowing and eventually reversing the tide of climate degradation.

Passive Design as a Power Source

Immediate adoption of passive architecture would offset a large percentage of carbon emissions and reduce the number of carbon sources to deal with, making it infinitely easier to solve our carbon problems. Unfortunately, a gradual approach is slightly more realistic when an immediate solution is necessary. According to Victor Delaqua's (2022) article, *"What Can We Learn About Zero Carbon from Lele's Work?"* in *ArchDaily*, "the construction sector is one of the main components responsible for the imbalance in which we find ourselves today, after all, it consumes natural resources on a gigantic scale and still we build buildings that do not collaborate with the maintenance of the environment". Passive architecture is collaborative with the surrounding environment, reduces energy needs by design, and can even create more energy than what is being consumed through solar and wind technologies. That excess energy can be used to power other homes that are not passive. This would create a self-sufficient and carbon-neutral system. To maximize the benefits of passive architecture, most of today's houses and buildings would need to be modified and future building and development must implement the methods of passive design. This is no small mandate but would be worth the effort if climate change could be ameliorated.

Power Sources

For this system to work, the definition of "passive architecture," "net-zero carbon," and "sustainable design" must be clearly defined and agreed upon in the building, scientific, and governmental sectors. Furthermore, it would be of crucial importance that the materials and means used to construct the buildings be standardized. New metrics must be designed to replace "the process method of assessment which has been criticized for ignoring emissions that occur further up the supply chain of manufactured goods" (Parkin et al, 2020). If the tools and machines used are powered using non-renewable energy sources, the combined amount of the burned fuel will emit a large amount of carbon. Many of the tools would need to be powered electrically. The batteries to those tools would have to be charged from renewable sources. This could require an international body to establish these guidelines and to ensure that they are followed. Although the United Nations cannot impose laws on countries, the UN may agree to assist in establishing guiding principles and inviting participation from the countries of the world.

Energy Sources

As far back as 2007, studies including one from Georgetown University have worked to establish a metric for measuring carbon emissions and determining net-zero buildings. Current practice and metrics still refer back to the Georgetown University study. If we transition to a net-zero economy, the demand for electricity will increase from multiple sources such as transportation. It is highly likely that the need for better ways of storing electricity will increase with this transition. It may be possible to include this aspect in the design features of the refurbished buildings. "In relation to carbon emissions, the question of materials used and embodied carbon will become more prominent" (Herrera et al, 2020). This implies that we need to be more mindful when it comes to choosing materials and ensuring that they are also carbon neutral. Materials like cement and steel require a lot of energy to produce. This will result in non-energy-related carbon emissions, which will make it much harder to achieve a net-zero goal. As mentioned, we also must innovate more accurate and efficient modes of measuring carbon footprints.

CONCLUSION

Sim Van der Ryn, as an architect at the forefront of eco-design, identifies seven principles of living buildings. These principles align with the fundamentals of passive architecture. This is the future of residential and commercial buildings. The principles are as follows.

Living buildings:

1. Harvest all their own water and energy needs
2. Adapt to specific local sites and climate
3. Create zero waste and pollution
4. Promote the health and well-being of all
5. Integrate systems to maximize efficiency and comfort.
6. Improve the health and diversity of local ecosystems.
7. Are beautiful and inspire us to higher levels of awareness and action.

We must reduce carbon emissions in a substantial way. Making changes to modern architecture and buildings must be considered as important to improving our atmosphere as the reduction of fossil fuel consumption and industrial pollution. If we want to make a dent in the amount of emissions that we produce today, we must change the way we live as well as the buildings in which we live. We must completely embrace a new way of building and construction. As we complete this task, unforeseen problems will arise, but with human ingenuity and commitment to eco-design, we can achieve the climate goals put forth through international agreement.

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